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Cover: Considered by some to be “perhaps the most spectacular tadpole of North America” (Altig and McDiarmid, 2015:194. *Handbook of Larval Amphibians of the United States and Canada*, Cornell University Press), this bird-voiced treefrog (*Hyla avivoca*) metamorph was photographed by John G. Palis on a partially flooded portion of LaRue Road where it passes through LaRue Swamp, Union County, Illinois (2 August 2020).

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The End of a Quarter-century Hiatus: Reconfirming *Regina grahamii* Baird and Girard, 1853 (Graham's Crayfish Snake) in DuPage County, Illinois, USA

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“As a budding 14-year-old herpetologist in 1962, I located an isolated and thriving colony of *Regina grahamii* (Graham's Crayfish Snake) in a cattail-willow slough in Villa Park, DuPage County, Illinois. The species was an intriguing novelty at the time and became a herpetological focal point for several years. Although the species was abundant at this site, I subsequently learned that it was actually among the rarest of Chicagoland's snakes (Pope, 1964). This further piqued my interest in studying the species. Unfortunately, the site was developed starting in the 1970s which resulted in a catastrophic alteration of the habitat and elimination of the *R. grahamii*. Not surprisingly, subsequent attempts to find *R. grahamii* at this altered site have failed. Loss of suitable habitat ensured the continued rarity of the species in the Chicago area. This has been affirmed by the decades-long absence of specimens and observations of the species. The recent discovery of *R. grahamii* in DuPage County is indeed refreshing and reassuring that the species has not been completely extirpated.”

- Robert “Bob” A. Young

Many semi-aquatic snake species are notorious for their secretive nature and infrequent detection (Durso et al., 2011), which have inevitably limited our knowledge of their natural histories and distributions relative to other guilds. Unfortunately, our hampered understanding may unintentionally postpone conservation efforts, making every bit of knowledge that much more crucial. Graham's crayfish snake (*Regina grahamii*) is a reclusive, specialized natricine of the Great Plains that feeds primarily on freshly molted crayfishes (Anton, 2019; Gibbons and Dorcas, 2004). Due to its hybrid affinity for both waterbodies and crayfish burrows, *R. grahamii* may be considered somewhat of a sub-aquatic-fossorial species.

R. grahamii occurs infrequently in Illinois—but can be locally common—and reaches the northeasternmost boundary of its range in the Chicago Region, where it is known from numerous scattered localities, often represented by just a single specimen (Pope, 1964; Smith, 1961; Anton, 1999). Several localities were known in DuPage County, Illinois, which were briefly summarized by Schramer and Anton (2018). To curb the loss of valuable anecdotal knowledge, we describe these historic localities in greater detail herein and report the first sighting of this species from DuPage County in 25 years.

Young (1973) described a site he referred to as the “Villa Park Swamp,” which hosted a relatively large *R. grahamii* population—it was not uncommon for him to observe a dozen or more individuals on any given visit during the early and mid-1960s (Young, 1973; R. A. Young, unpublished data). The site consisted of a shallow (<1 m depth), stream-fed marsh (Sugar Creek, Salt Creek Drainage), containing cattails (*Typha* sp.), duckweed (*Lemna* spp.), water lilies (*Nymphaea* sp.), willows (*Salix* spp.), and cottonwoods (*Populus deltoides*) (Young, 1973; R. A. Young, pers. comm.). Several small, private rectangular man-made ponds situated at the northeast boundary of the marsh were used for commercial crayfish harvest and produced many *R. grahamii* as well (R. A. Young, pers. comm.). Pre-

served specimens from this site are accessioned in the Louisiana State University Museum of Natural Science (LSUMZ 88726) and Northern Illinois University teaching collection (HDW 656–658). Other specimens, purportedly given to the Field Museum of Natural History, were apparently lost.

Young (1973) reported declines associated with habitat disturbance and destruction after 1966, which prompted him to translocate neonates from two gravid females to a marsh at the southeast corner of Churchill Woods Forest Preserve (R. A. Young, pers. comm.). The release site was subsequently disturbed during the construction of the Interstate 355 overpass and electrical infrastructure. It is unknown whether the translocation was successful as no subsequent observations were made (R. A. Young, pers. comm.; Ludwig et al., 1990, 1992). The original “Villa Park Swamp” site is now Sugar Creek Golf Course and a Walmart Supercenter. The retention area north of the Walmart parking lot is dominated by cattails (*Typha* spp.) and spikerush (*Eleocharis* sp.)—not a single crayfish burrow was noted during a visit during June of 2016 (T. D. Schramer, pers. obs.).

In the late 1960s, Robert “Bob” A. Young (pers. comm.) also reported one live and two dead-on-road *R. grahamii* from west-bound North Avenue—just west of the Grace Street junction—at a wetland complex once known as “Grace Street Marsh” (south of Fullerton Park; Westwood Creek, Salt Creek Drainage). At the time, the marsh was dominated by cattails (*Typha* spp.) and graminoids with little woody encroachment (R. A. Young, pers. comm.). Although still mostly intact today, the marsh has been heavily disturbed and degraded, with the surrounding development causing major hydrological changes and a transition from hemi-marsh to open-water marsh. No *R. grahamii* were discovered during the 1987–1991 Forest Preserve District of DuPage County surveys, which included this site (Ludwig et al., 1990; Ludwig et al., 1992). The marsh is currently surrounded by buckthorn (*Rhamnus* spp.) and reed canary grass (*Phalaris arundinacea*), with cattails (*Typha* spp.)

1. Boone County Conservation District, 603 N Appleton Rd, Belvidere, IL 61008.

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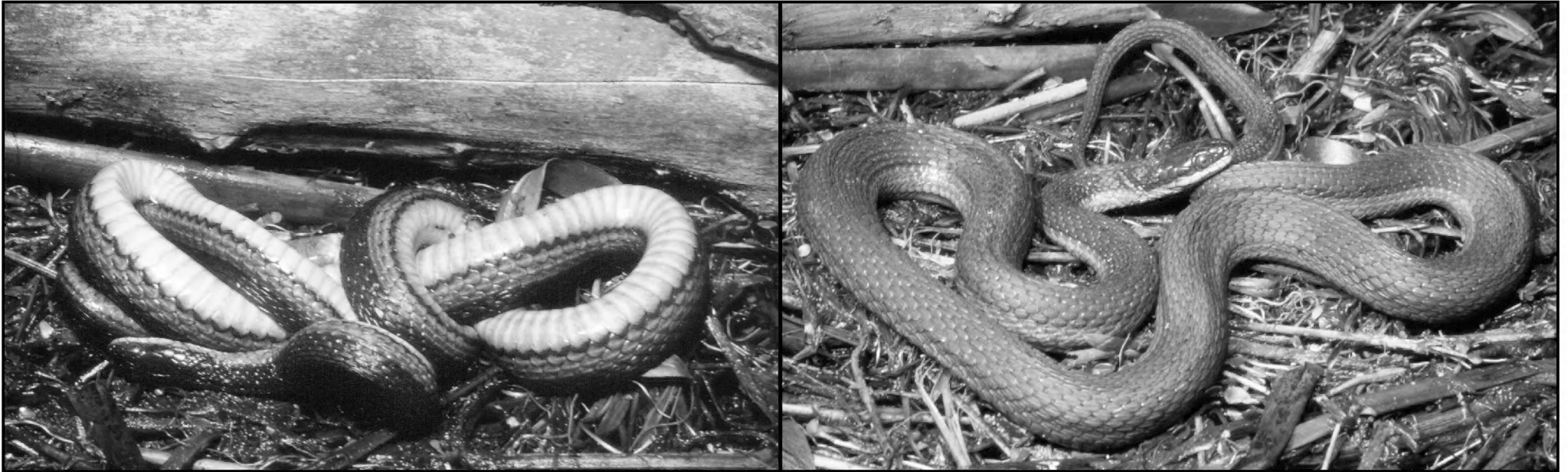


Figure 1. Ventral and dorsal aspects of a male Graham's crayfish snake (*Regina grahamii*) found at West Chicago Prairie, DuPage County, Illinois during May of 1995 by Kevin Luby. Photographs courtesy of Michael Redmer.

being the dominant emergent plant (T. D. Schramer, pers. obs.).

During May of 1995, an adult male *R. grahamii* (Figure 1) was discovered at West Chicago Prairie Forest Preserve by Kevin Luby (Van Matre, 1995; M. Redmer, pers. comm.). The snake was found basking on a trail that crossed wet prairie, sedge meadow, and emergent marsh habitats (Kress Creek, West Branch Drainage) (M. Redmer, pers. comm.). That observation (INHS photo voucher 26415) represented the first record for the species at the site, and the last record for DuPage County—until now.

On 16 June 2020 at 1655 hr, Adam D. Dorn and Colin P. Jamen observed a gravid female *R. grahamii* (Figure 2; HM 315096; HerpMapper, 2020) basking in low-lying vegetation in near vicinity of the 1995 record detailed above (sunny; 28.3°C; 747 mmHg; 40% humidity). The snake's snout-vent length and tail length measured 671 mm and 54 mm, respectively, although the tail was truncated. The meristic data were consistent with those reported by previous authors (Table 1). Given its cleared eyes and the presence of sloughing skin, the snake appeared to be in the later stages of ecdysis. The habitat within the immediate point of capture consists of remnant wet-mesic prairie featuring sporadic muck-soil marshes dominated largely by emergent sedges (*Carex* spp.), cattails (*Typha* spp.), sandbar willow (*Salix exigua*), water smartweed (*Persicaria amphibia*), duckweed (*Lemna* spp.) and river bulrush (*Bolboschoenus fluviatilis*), with blue-joint grass (*Calamagrostis canadensis*), white-panicle aster (*Symphyotrichum lanceolatum*), and dark-green bulrush

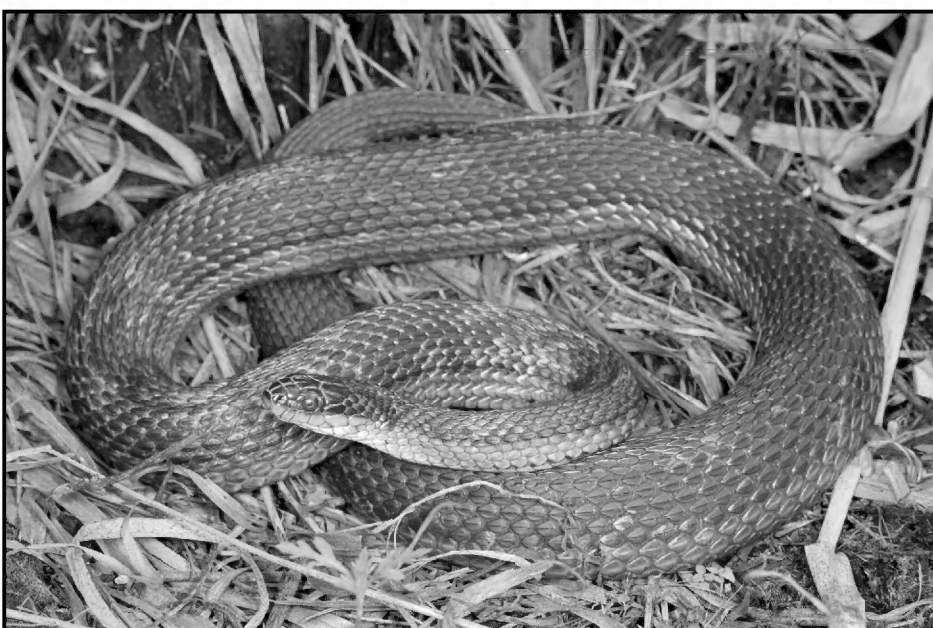


Figure 2. Gravid female Graham's crayfish snake (*Regina grahamii*) found at West Chicago Prairie, DuPage County, Illinois, on 16 June 2020. Photograph by Nathan Kutok.

(*Scirpus atrovirens*) occurring as subdominant associates.

Species often occur at lower densities and greater isolation at the periphery of their ranges, warranting conservation attention and prioritization (Steen and Barrett, 2015). However, this peripheral phenomenon is typically associated with reduced detection, which may hinder and constrain our capacity for knowledge acquisition, thus impeding conservation progress. This difficulty can be exacerbated further by the cryptic life history traits and habitat specializations of the focal species (e.g., Durso et al., 2011), including those intrinsic to *R. grahamii* in particular. Certainly, one detection every 25 years is a direct testament to the secretive nature of this species and ineffectiveness of relying on passive encounters for monitoring. Presence-absence site occupancy models, which incorporate detection probability, should be explored in the future, along with aquatic funnel trapping, to trace this species' use of the landscape (Durso et al., 2011).

In northwestern Arkansas, Baecher and colleagues (2018) utilized aquatic minnow trapping to successfully document *R. grahamii* in the region for the first time in over half a century. Moreover, *R. grahamii* showed a stronger preference toward restored prairie habitats in comparison to other more-generalist, semi-aquatic snake species (Baecher et al., 2018). Indeed, aquatic funnel traps, which had accumulated crayfish, have been successful in detecting *R. grahamii* in both Lake (A. Sacerdote-Velat, pers. comm.) and Grundy (INHS 20119) Counties, Illinois. Combining this method with aquatic drift fences could prove effective, particularly at more degraded sites (i.e., Grace Street Marsh and the Churchill Woods translocation site; Schramer and Anton, 2018). Perhaps environmental DNA (eDNA) may also prove effective in the future once methods become more refined, as recent investigations on secretive snake species have had limited success (e.g., Ratsch et al., 2020).

Although DuPage County—and the Chicago Region at large—has suffered immense losses to its biological heritage, some remnants of historic locales (or nearby sites) remain despite the odds. However degraded and/or neglected, these sites possess valuable information on the requirements and sensitivity of *R. grahamii* regardless of contemporary presence. Ultimately, we hope the data presented herein prompt and inspire future explorations of these sites and the dissemination of any withheld or future-gained knowledge.

Table 1. Compiled meristic characteristics for *R. grahamii* from northern Illinois (Smith, 1961), DuPage County (Young, 1973), and the specimen reported herein. Asterisks (*) denote confounded data due to a truncated tail. Summary data calculated or reported from Young (1973) exclude individuals with incomplete tails where applicable (i.e., subcaudals, tail length and total length).

	Smith (1961) Northern Illinois (n = 13)		Young (1973) DuPage County (n = 7)		This study HM 315096 (n = 1)
Characteristic	Range	Mean	Range	Mean	
<u>Ventrals</u>					
♂.....	162–170	165.7	164–170	168	—
♀.....	158–169	161.6	157–159	158	154
<u>Subcaudals</u>					
♂.....	62–65	63.8	62–65	64	—
♀.....	57–64	59.5	51–57	53	21*
<u>Tail length as a percentage of total length</u>					
♂.....	18.3–20.4	19.5	18.3–19.0	18.7	—
♀.....	17.0–19.7	18.8	15.0–17.2	16.4	7.4*
<u>Snout–vent length [tail length] (mm)</u>					
♂.....	—	—	495–670 [115–150]	558 [128]	—
♀.....	—	—	630–835 [120–140]	705 [130]	671 [54*]

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Notes on Mexican Herpetofauna 35: Use of Artificial Shelters by Pairs of *Gerrhonotus parvus* Knight and Scudday, 1985 (Squamata: Anguidae), with Notes on Behavior and Interactions in Captivity

David Lazcano¹, Sandra C. Hernández-Bocardo¹ and Larry David Wilson²

Abstract

We studied pairs of pygmy alligator lizards, *Gerrhonotus parvus*, in four experimental units in captivity. Each experimental unit contained two artificial shelters. In general, pairs were found sheltering together in 31.5% of our observations. When the results from these experimental units are compared, each pair spent a different amount of time together, but no pair was found sharing a shelter in more than 44% of the corresponding observations.

Resumen

Estudiamos parejas de lagartijas cocodrilo pigmeos, *Gerrhonotus parvus*, en cuatro unidades experimentales en cautiverio. Cada unidad experimental contenía dos refugios artificiales. Después de 58 días de experimento, obtuvimos 464 observaciones. En general, las parejas se encontraron refugiándose juntas en 31.5% de nuestras observaciones. Cuando se comparan individualmente estas unidades experimentales cada par pasó una cantidad diferente de tiempo juntos, pero no se encontró ningún par compartiendo un refugio en no más de 44% de las observaciones correspondientes.

Background

The genus *Gerrhonotus* Wiegmann 1828 is endemic to North America and is represented by seven species: *G. farri* Bryson and Graham 2010; *G. infernalis* Baird 1859 (1858); *G. lazcano* Banda-Leal, Nevarez de los Reyes, and Bryson 2017; *G. liocephalus* Wiegmann 1828; *G. lugoi*, McCoy 1970; *G. ophiurus* Cope 1866; *G. parvus* Knight and Scudday 1985. The distribution of the group is complex; the larger species have broad ranges, and the smaller species are range-restricted. The most widely distributed species are *G. liocephalus* in western and southern Mexico and *G. infernalis* in central and northern Mexico and southern Texas (Good, 1988, 1994). The remaining five species have restricted distributions, known from small areas and only a few individual specimens.

Relatively little is known about the biology of *G. farri*, *G. lazcano*, *G. lugoi* and *G. parvus*. For *G. lugoi*, there is a report of reproduction in captivity, courtship, and litter size (Lazcano et al., 1993). For *G. parvus*, there is more detailed information about its natural history (Bryson et al., 2003), as well as its distribution, litter size, sympatric herpetofauna, potential predators, and a very limited amount of information on its habitat and captive management (Banda-Leal et al., 2013; Banda-Leal et al., 2014a, b; Lazcano et al., 2015; Banda-Leal, 2016; Hernández-Bocardo and Lazcano, 2018; Hernández-Bocardo et al., 2019). *Gerrhonotus farri* and *G. lazcano* are known from a single specimen each, with accordingly limited information for each species (Bryson and Graham, 2010; Banda-Leal et al., 2017).

To protect threatened and endangered populations there is a need to maintain and propagate many herpetofaunal species in their natural habitat or in captivity (Braun et al., 2010; Santoyo-Brito, 2012; Dodd, 2016). In an effort to understand the use of microhabitats by *Gerrhonotus parvus*, we conducted experiments with captive specimens using artificial shelters. The use of artificial shelters is a powerful tool for herpetological surveys and can be important to understanding a species' distribution,

habitat preferences and temperature requirements (Fellers and Drost, 1994; Doak, 1995; Webb and Shine, 2000; Howes and Loughheed, 2004; Amo et al., 2007; Bissonette and Adair, 2008; Hampton, 2007; Lettink, 2007; Lettink and Cree, 2007; Arida and Bull, 2008; Croak et al., 2008; Davis et al., 2010; Scheffers et al., 2009; Thierry et al., 2009; Andersson et al., 2010; Grillet et al., 2010; Lelièvre et al., 2010; Monasterio et al., 2010; Willson and Gibbons, 2010; Lettink et al., 2011; Michael et al., 2012; Staugas et al., 2013; Croak et al., 2013; Ebrahimi et al., 2012; BenDor et al., 2015; Dodd, 2016; Sutherland et al., 2016; Mundo-Hernández et al., 2017; Michael et al., 2018).

Materials and Methods

Over the past three years, we have been working with artificial shelters for *G. parvus* (Esquivel-Arévalo, 2017; Hernández-Bocardo and Lazcano, 2018; Hernández-Bocardo et al., 2019). Individuals were maintained in wooden units (90 cm long × 68 cm wide × 37 cm high), with a front and top mesh for better ventilation (Figure 1). Temperature of the room was maintained at 21–24°C; photoperiod was 12:12 L:D. The experimental period was for 58 days from August to September and the indi-



Figure 1. View of the room holding the experimental units. Photograph by Francisco José Herrera-Maldonado.

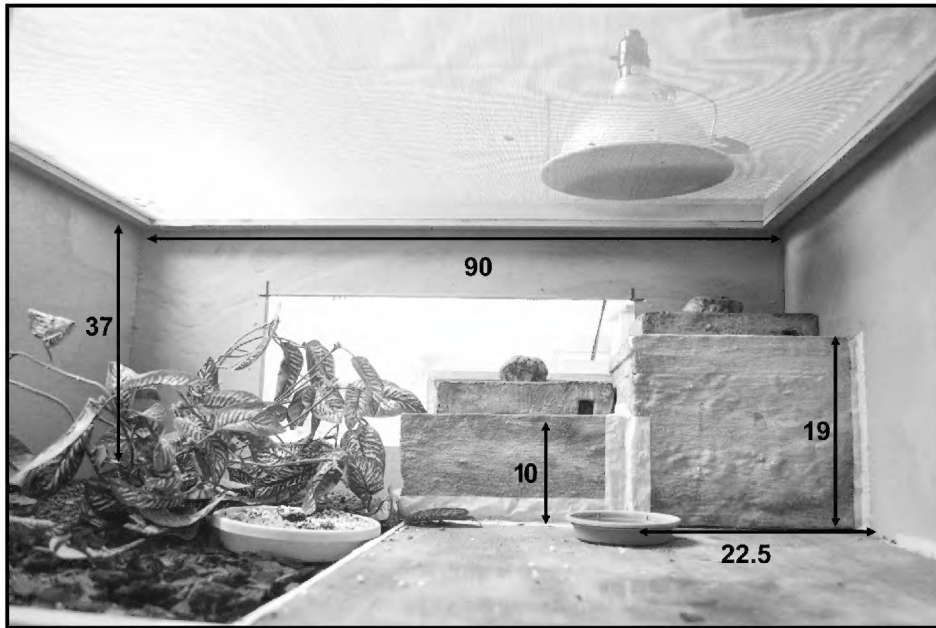


Figure 2. The interior of one of the experimental units. Photograph by Francisco José Herrera-Maldonado.

viduals were fed twice a week (on Tuesdays and Thursdays). They received 21 feedings during this experimental period. Their diet consisted of a variety of food items, including mealworms (*Tenebrio molitor*), crickets (*Acheta domesticus*), Madagascar hissing cockroaches (*Gromphadorhina portentosa*), lobster roaches (*Nauphoeta cinerea*) and greater wax moth (*Galleria mellonella*); all food items were supplemented with alternate dustings of finely powdered Repashy Super Foods (Repashy Ventures, Inc. Oceanside, CA 92056) and Revipet vitamins and minerals (PETMMAL S.A. DE C.V. Cuautitlán Izcalli, Estado de Mexico, Mexico). Each experimental unit included two square platforms (22.5 cm × 22.5 cm). One platform was at a height of 19 cm; the other at a height of 10 cm above the floor of the unit (Figure 2). Both the high and the low platforms held a single refuge (20 cm long × 12 cm wide × 4.5 cm high; Figure 3). The animals were housed in pairs as follows: Pair 1: ♀ JBL-049 (7.54 g) and ♂ JBL-048 (8.63 g); Pair 2: ♀ UANL-7720 (7.85 g) and ♂ JBL-043 (9.33 g); Pair 3: ♀ JBL-051 (5.41 g) and ♂ UANL-6904 (8.00 g); Pair 4: ♀ JBL-052 (7.41 g) and ♂ N/N (6.75 g) (Figure 4).

Before introducing the females, the four experimental units (E.U.) used had been occupied by the males for a year. These units and the artificial shelters are described above (but also see Hernández-Bocardo and Lazcano, 2018; Hernández-Bocardo et al., 2019).

During the 58-day experiment, we measured the temperature twice daily inside each artificial shelter in the four E.U.s; once at 10:00 h (Period 1) and once at 16:30 h (Period 2). When the

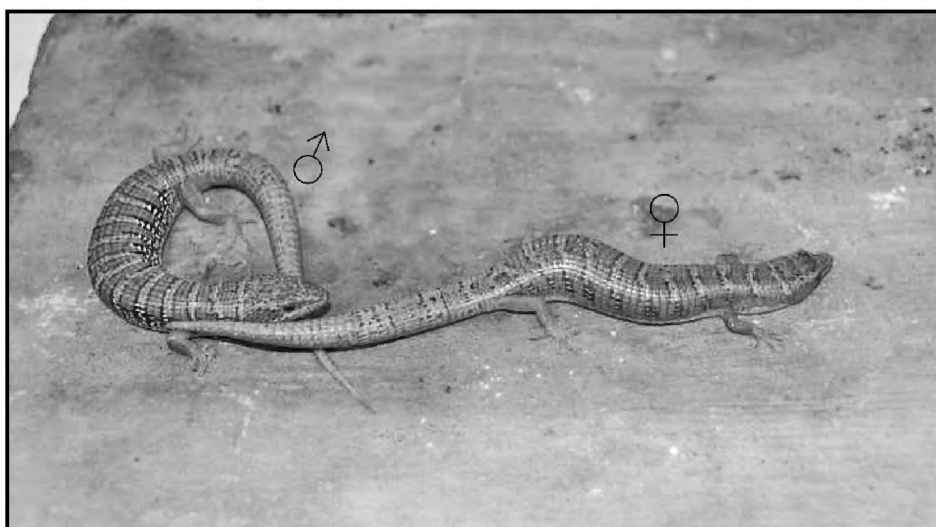


Figure 4. A pair of *Gerrhonotus parvus*, as seen when their artificial shelter was lifted.. Photograph by Francisco José Herrera-Maldonado.



Figure 3. One of the artificial shelters. Photograph by Francisco José Herrera-Maldonado.

morning temperatures were taken, the higher shelter did not have a heat lamp on, but the heat lamp was on in the higher shelter when the afternoon temperatures were taken. This provided a temperature gradient for the two similar shelters, as the refuges in the lower position never had a heat source. We also obtained information about whether the animals were active or moving outside their refuge at both times. In addition, the units were misted every Monday, Wednesday and Friday at 11:00 h. Observations were made by simply lifting the shelters to see where the animals were. At the end of the 58-day period during which the pairs were housed in the E.U.s to follow their behavior, we had a total of 464 observations (two per day in each of the four E.U.s).

Results

During Period 1, when there was no temperature gradient, the shelters reached temperatures between 16.4°C and 23.8°C. During Period 2 a temperature gradient was generated; the shelter on the High Platform reached temperatures between 23.8°C and 38.2°C, with an average of 29.7 °C. The shelters on the low platform presented temperatures between 21 °C and 31.8°C, with an average of 25.3°C. As for body temperatures, the individuals registered from 21.2 to 34.2°C ($\bar{x} = 23.6 \pm 3.3^\circ\text{C}$).

Out of the total of 464 observations, pairs were found sharing a shelter 146 times (31.5%). Each of the four pairs was observed 116 times. The number of times each pair was seen together in a shelter was recorded as follows: Pair 1 — 30 (25.9%); Pair 2 — 51 (44.0%); Pair 3 — 47 (40.5%); Pair 4 — 18 (15.5%). Most of the pairs used the shelter on top of the low platform, except for Pair 3, which shared the high platform on 44 (93.6%) of the 47 times found together.

Here are some of our foraging behavior observations. On 21 occasions when individuals were fed while sharing the same shelter, no agonistic behavior was seen. Sometimes one individual would steal the food item that was designated for its mate from the tweezers, but this did not provoke any “aggressive” reaction. As for physical interactions between the paired individuals, little to nothing was observed; on occasion, when sharing a shelter, the individuals were found resting one on top of the other, but no mating behavior was observed, and no aggressive reaction against the observer interference when registering data.

In general, no defensive behavior, from either males or females, was observed.

Discussion and Conclusion

In general, lizards of the family Anguidae have been reported as solitary; individuals are rarely found together and only seem to interact during mating season (Beck, 2009; Lemos-Espinal et al., 2015; Yasuda, 2015). The latter author speculates that, as cannibalism has been detected in *Elgaria*, alligator lizards may have low densities to minimize intraspecific interactions which could result in predation events. This tendency to be solitary may explain why individuals were found together on relatively few occasions. García-Bastida (2016) did not report finding *Gerrhonotus infernalis* sharing a common refuge. However, in July she found one female with 3 babies and 11 eggs. She never found any pairs or observed reproductive behavior. She documented finding 77 individuals during her study period (22 females, 34 males, 8 juveniles and 13 unsexed). Most of the 34 males had tooth marks to some degree on their lower jaw, presumably inflicted as a result of territorial behavior during the breeding season. In *Gerrhonotus parvus*, some males found in the wild also presented bite marks on the lower jaws, but not as noticeable as in *Gerrhonotus infernalis*. The presence of bite marks is associated with agonistic behavior. Such behavior is very common with anguid genera (Formanowicz et al., 1990).

Even though we did not observe or record any evidence of aggressive precopulatory or copulatory behavior, agonistic behavior has been reported for the species by three males that had been confined in a large experimental unit for some days (Lazcano et al., 2015). When put together they immediately presented aggressive behavior.

Agonistic behavior was also documented in another event (Hernández-Bocardo and Lazcano, 2018). Upon introducing a female into an experimental unit occupied by the alpha male, we discovered the male biting the female on the dorsolateral portion of the head, with a substantial amount of blood on her, on the

male's mouth and on the ground.

Our results on the sharing of artificial shelters shed some light on the behavior of the species when encountered as couples, at least in an artificial environment. But in the wild this has never been observed.

Our observations on the timing of egg-laying behavior differ from those documented by Lazcano and Banda-Leal (2017), who found a gravid female on 30 March 2012 in the locality of Cañón de Reflexiones, Santa Catarina, Nuevo León. On 9 June 2012 that female laid 6 eggs, which didn't develop. The same authors also mention finding three gravid females in the locality of Cañón de San Isidro, Santiago, Nuevo Leon, on 22–23 April, that then deposited their eggs between 4 and 6 July.

Two of our females involved in this experiment, JBL-049 and JBL-052, had previously laid eggs (Lazcano and Banda-Leal, 2017). After the experimental period that ended on 29 August we found that female JBL-49 (Pair 1) had laid four unfertilized eggs in the corner closest to the terrarium door, but before that we had noticed that on 6 August female JBL-052 (Pair 4) had laid two unfertilized eggs next to a container holding a moistened Perlite substrate. These times are not consistent with the information from females obtained in the wild.

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Notes on Reproduction of the Spotted Chorus Frog, *Pseudacris clarkii* (Anura: Hylidae),
from Oklahoma and Texas

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Abstract

I conducted a histological examination of gonads from 39 *Pseudacris clarkii* (38 from Oklahoma and 1 from Texas). Males contained sperm from all months examined: February to July and September. The smallest mature male (sperm in lumina of seminiferous tubules) measured 21 mm SVL. The smallest mature female (spawning condition) measured 23 mm SVL. My findings of reproductively active males (spermiogenesis) from four seasons and one female in spawning condition from July support findings that *P. clarkii* is an opportunistic breeder that can, besides breeding in winter and spring, also reproduce in summer and autumn (see Dodd, 2013).

The spotted chorus frog, *Pseudacris clarkii* (Baird, 1854) occurs from south-central Kansas to the Texas Gulf Coast and just into Mexico, through much of the Texas Panhandle and almost into Arkansas (Dodd, 2013). In Oklahoma it prefers moist areas in seasonally wet lands, in tallgrass and mixed prairies (Sievert and Sievert, 2011). *Pseudacris clarkii* usually utters its breeding call from under banks or from clumps of vegetation (Bragg and Smith, 1942). The most detailed work on *P. clarkii* reproduction is by Bragg (1943). Breeding is reported to occur from January to early June, occasionally in summer to early October (Sredl, 2005). The biology of *P. clarkii* is summarized in Pierce and Whitehurst (1990). In this paper, I present data from a histological examination of *P. clarkii* gonads from Oklahoma and Texas. Utilization of museum specimens for obtaining reproductive information avoids removing additional animals from the wild.

A sample of 39 *P. clarkii* (38 from Oklahoma and one from Texas OMNH 39511) (Appendix) collected 1934 to 2017 consisting of 33 males (mean snout–vent length, SVL = 25.2 mm $\pm$ 1.9 SD, range = 21–28 mm) and 6 females (mean SVL = 27.7 mm $\pm$ 4.1 SD, range = 23–33 mm) was examined from the herpetology collection of the Sam Noble Museum (OMNH), University of Oklahoma, Norman, USA.

A small incision was made in the lower part of the abdomen and the left testis was removed from males and a piece of the left ovary from females. Gonads were embedded in paraffin, sections were cut at 5 μ m and stained with Harris hematoxylin followed by eosin counterstain (Presnell and Schreiber, 1997). Histology slides were deposited at OMNH. An unpaired *t*-test was used to test for differences between male and female SVLs (InStat, vers. 3.0b, Graphpad Software, San Diego, CA).

The testicular morphology of *P. clarkii* is similar to that of other anurans as described in Ogielska and Bartmańska (2009a). Within the seminiferous tubules, spermiogenesis occurs in cysts which are closed until the late spermatid stage is reached; cysts then open and differentiating sperm reach the lumina of the seminiferous tubules (Ogielska and Bartmańska, 2009a). There was typically a tangled mass of spermatozoa in the lumen of the seminiferous tubule and a ring of germinal cysts located on the inner periphery of each tubule. All 33 examined *P. clarkii* testes were undergoing spermiogenesis: February (N = 1), March (N = 3), April (N = 7), May (N = 8), June (N = 4), July (N = 9), September (N = 1). The smallest mature male (spermiogenesis) of *P. clarkii* measured 21 mm SVL (OMNH 41678) and was

from June. Wright and Wright (1933) reported *P. clarkii* adult males (as *Pseudacris nigrita clarkii*) ranged from 20–29 mm. The one *P. clarkii* from Texas (OMNH 39511, SVL = 28 mm) was a male from February.

The mean SVL of *P. clarkii* females was significantly larger than that of males (*t* = 2.4, *df* = 37, *P* = 0.023). The ovaries of *P. clarkii* are similar to those of other anurans in being paired organs lying on the ventral sides of the kidneys; in adults the ovaries are filled with diplotene oocytes in various stages of development (Ogielska and Bartmańska, 2009b). Mature oocytes are filled with yolk droplets; the layer of surrounding follicular cells is thinly stretched. Two stages were present in the spawning cycle (Table 1): (1) Ready to spawn, in which mature oocytes predominated; (2) Not in spawning condition, in which previtellogenic oocytes predominated. One May (OMNH 32990) and one July female (OMNH 27582) were in spawning condition (Table 1). The smallest mature female (spawning condition) of *P. clarkii* measured 23 mm SVL (OMNH 32990) and was from May. Wright and Wright (1933) reported *P. clarkii* (as *Pseudacris nigrita clarkii*) adult females ranged from 25 to 31 mm.

One of the two *P. clarkii* females in spawning condition (OMNH 27582) (Table 1) contained atretic oocytes. Atresia is a widespread process occurring in the ovaries of all vertebrates (Uribe Aranzábal, 2009). It is common in the amphibian ovary (Saidapur, 1978) and is the spontaneous digestion of a diplotene oocyte by its own hypertrophied and phagocytic follicle cells which invade the follicle and eventually degenerate after accumulating dark pigment (Ogielska and Bartmańska, 2009b). See Saidapur and Nadkarni (1973) and Ogielska et al. (2010) for a detailed description of the stages of follicular atresia in the frog ovary. Atresia may influence the number of ovulated oocytes (Uribe Aranzábal, 2011) and can remove females from the breeding population (Goldberg, 2019).

Table 1. Conditions in the spawning cycle of 6 adult *Pseudacris clarkii* females from Oklahoma.

Month	<i>n</i>	Ready to spawn	Not in spawning condition
May	1	1	0
June	2	0	2
July	1	1	0
September	1	0	1
October	1	0	1

In conclusion, my findings of reproductively active males (spermiogenesis) from four seasons and one female in spawning condition from July (Table 1) support findings of others (see Dodd, 2013) that besides breeding in winter and spring, *P. clarkii* is an opportunistic breeder that can also reproduce in summer and autumn (Table 2).

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Table 2. Months of breeding by state for *Pseudacris clarkii*.

Locality	Breeding period	Source
Kansas	March to August	Collins et al., 2010
Oklahoma	April–May, October?	Sievert and Sievert, 2011
Oklahoma	Spring–Summer	Bragg, 1943
Texas	September	Kennedy, 1958
Texas	February to October	Lindsay, 1958
Texas	Spring and Fall	Blair, 1961
Texas	January to June	Tipton et al., 2012

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Appendix

Thirty-eight *P. clarkii* from Oklahoma and one from Texas* examined (by county) (N = 39) from the herpetology collection of the Sam Noble Museum (OMNH), The University of Oklahoma, Norman, Oklahoma, USA.

County: **Beckam:** 35565, 35566; **Carter:** 27581; **Cleveland:** 39084, 39085, 39320– 39322; **Comanche:** 27730, 27771, 27772, 32990-32994, 33039, 33042, 33043, 33046, 33047; **Ellis:** 41678, 41682, 41691; **Greer:** 31141, 39509, 39510; **Marshall:** 27582–27584, 27726, 27728, 27729, 27732; **Murray:** 40102; **Pottawatomie:** 18814, 47200; **Woodward:** 47206; **Texas* Denton:** 39511.

The Regal Horned Lizard (*Phrynosoma solare*)

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“... and the lizards are all above average?”

The author at times suffers from these delusions of grandeur. He visualizes people the world over reading these columns of his. He tries to imagine somebody from a place like the Komodo Islands getting to his traditional sign-off, and seeing the words “and the lizards are all above average.” I can only imagine this person (who resides in a place where a local lizard can take out a water buffalo) accidentally snorting righteously indignant snot into his gourd full of goat’s milk. (Said milk produced by a goat that is in turn heavily guarded from slobbering, ten-foot-long lizards.) I envision this imaginary Komodian, whom we shall name Bill, scornfully saying (pay attention readers—this is Bill talking, and he doesn’t chew his cabbage twice): “Peh! This *idiot* from Arizona thinks *his* lizards are above average? Come over here, and we’ll show you some *real* lizards, pal!” Much the same could be said about other folk named Bill in Africa, South America, Mexico, Australia, or any number of places around the world. Heck, we might even throw Florida into the works—if we want to include herpetological *cheaters* who have stacked their regional deck with nearly every lizard species possible. Any one of these imaginary Bills from various corners of the world could easily wax haughty and *try* to put me in my place with that last line of my Garrison Keillor rip-off. But they had better eat their Wheaties before they do. I won’t be taking any bullshit from anybody. I *could* of course retort to Bill (whom I’m starting to dislike already) with a prideful boast about some of Arizona’s “lightweight” lizards. We speak of such gems as Gila Monsters, Chuckwallas, Leopard Lizards, Collared Lizards, Desert Iguanas, and more types of whiptails than you can shake a stick at—including one that reaches more than 18 inches in total length. But if I *really* wanted to go for the throat, I’d say to Bill: “Oh yeah, buddy? Well, we got horny toads! What do you think about *that*, huh?” Yup! We not only have horny toads, we have *seven species of horny toad*! And all seven of those can be found in the southern 20% of our state. It would be entirely possible to find all seven in one day here. Like the proverbial brave little tailor (Grimm brothers, 1812), we *could* get “seven with one blow!” And Arizona is the only state in this great nation of ours where that is possible.

Regal Horned Lizards in Arizona, and those who study them

How he talks! He thinks he can find all seven species of Arizona’s horned lizards in one day? Nope! He doesn’t think that at all. He knows it is possible, but truth be told, he’d do well to find a Regal Horned Lizard—the species that he knows best—in this challenging seven-with-one-blow adventure of his. A few scant weeks ago, I started this column with the foolish notion that I knew enough about the Regal Horned Lizard to share something new with the world. But then I made the mistake of talking to the two most knowledgeable people in the world about them. We speak first of Dr. Brian Sullivan of

Arizona State University. Brian has spent the past ten years observing Regals (as we shall call them at will throughout this piece), and in 2015, began an ongoing radio-telemetry study on them. (If you ever *really* want to know what a lizard is doing, stick a transmitter on it!). The other person who I spoke with was that whale amongst minnows in the horned lizard world, Dr. Wade Sherbrooke. Both have been wonderfully collaborative, but each time I shared an observation that I thought was new or unique, one or the other of them had not only seen it, but had already done a paper on it. That’s what I get for bringing spaghetti to the Pope! But seriously, thank you both! I am hopeful that there are some surprises for you with what follows.

It is a daunting task for this herper to write about any type of horned lizard without first expressing the strong sentimental attachment that I feel for them. I do believe it is not possible to know them without loving them. That is especially true for those of us who were exposed to them at an early age. As none of you will remember, my very first monthly column for this publication centered on the Texas Horned Lizards (*Phrynosoma cornutum*) that were made widely available to those of us in the Chicago area and well beyond through the pet trade. We will not dwell on the yin and yang that the devastating effects of supply and demand had on populations of these delightful and unique creatures. I will instead continue to revel in the good personal fortune that landed me in a place that not only has wild populations of tortoises, Gila Monsters, and rattlesnakes, but a generous smorgasbord of horny toads as well.

I would be remiss in my duties if I did not mention some natural history aspects of the Regal. My personal favorite piece on them can be accessed on the website of the Tucson Herpetological Society. To get there, simply type “Tucson Herpetological Society,” into your favorite search engine, and she pops right up. Look at the top of the page, and look for the drop-down menus there. Let your mouse hover over “Reptiles and Amphibians,” and note that your second choice is “lizards”. Click that, and select “Regal Horned Lizard” from the many offerings of all the above average lizards that can be found here. This account, written by Jim Rorabaugh, is as good as anything out there, and the literature cited section is outstanding. But I will not let myself off so easy as to drop it all on Jim. I’ll pick off a few details on Regals, using memories from field experiences, and literature. We start by showing an image of one. (Figure 1). They are the largest horned lizards to occur in the continental USA. Sullivan and Sullivan (2017) report a maximum snout–vent length (SVL) of 125 mm (5 inches). That sounds about right to this author, as I once measured a whopper that was six inches in total length. (Figure 1 right). They do not lead exceptionally long lives. A Swiss gentleman named Bertrand Baur (since I’m dropping names all over the place, I will say that Bertrand and I had some good times together here in Arizona) kept an individual for just over eight years. As this



Figure 1. (Left) A Regal Horned Lizard (*Phrynosoma solare*). (Right): A whopper! The author reports in the text that the largest Regal he has ever measured was six inches total length. This is that one. As the lizard is in the author's left hand, I can offer as a size perspective that my hand is four inches wide at the point where the left side of the lizard crosses it. Both images by the author.

individual was half grown when he acquired it, we can guess that it was pushing ten years in age (Baur, 1986). In May of 2018, I was at a herp conference where Brian Sullivan told the audience that the average life expectancy of those Regals under his watch was four years. We will touch on the diet of the Regal in this piece soon, but “88.8% harvester ants” is suggested by Rorabaugh, and “90%” in too many other places to cite here (but see Ivanyi, 2009). Reproduction will be discussed later. In finishing this section up, I strongly suggest that Rorabaugh's write-up on the Regal Horned Lizard is about as thorough and concise as anything out there. It is also easily accessible. If you want to know more than what I'm giving you here—go for Rorabaugh first!

Oddly enough, I have a vivid memory of that very first tortoise, that very first Gila Monster, and that very first rattlesnake that I encountered in the wild. But that first Regal Horned Lizard? Poof—gone from memory. Perhaps that is because upon moving to Arizona in 1981, I accidentally plopped myself into the middle of one of the densest populations of Regals in the state. From 1981 to 1987, we lived near the south bank of the Rillito River, which is *the* major east-west drainage of Tucson. We were also very close to where the Rillito River converges with the Santa Cruz River, which is *the* major north-south drainage of Tucson. Hence, we were close to two major wildlife corridors. Our mobile home park was the westernmost outpost of the south bank of the Rillito, as everything west of that was designated as flood plain. In 1987, we relocated to the north side of the Rillito—almost directly across the river from the first place. We lived in this location until 2003. If anything, there were *more* Regals there than the first place—at least initially.

I am now slugging my way toward that *one thing* that I have done that I would bet large sums of money that no living human being has ever done before. We are going to look at the Regal through the eyes of a herpetological generalist who encounters them randomly while seeking other things. We're going to start this process using a technique that I have recently seen used in a

number of email discussions. This artful form of maximizing herpetological yield per field trip is done when *somebody* has a great day in the field, and then extrapolates from that *one day* of data to proclaim that his or her field site is the best in the world as a result. I thought I would try this method out with the Regal Horned Lizard, and see how I like it. I mentioned that from the years 1981 to 2003, I lived in two different Regal Strongholds. When I throw out everything else that happened during that 22-year time period, and focus only on the best, I come up with three events where 41 different Regals were encountered during five hours total of my personal field time. Since a true disciple of maximizing herpetological yield would *never* count the hours of those who were with him at the time, I come up with 7.32 Regal Horned Lizards per hour of field effort observed, or one every 8.2 minutes. **EYE LIKE IT!** Yeah, people! Come herping with me! We shall see a Regal Horned Lizard every 8.2 minutes. And while we're at it, we'll pick off all seven species of horny toads in one day. *Both* are equally possible.

Now we'll discuss the other extreme—the Roger Repp, Herp King of Southern Arizona, method of counting herps. With my method, when venturing out on any herping trip, I am on the clock from the second that I leave my driveway until the second I return. Where Regal Horned Lizards are concerned, there is the chance of an encounter no matter what I do, or no matter which way I go. There are only three directions that I can drive when I leave my house, and Regals have been encountered with all three. There is also the chance that I will see over 300 (or more) different herps, of ten different species (or more), without seeing a single Regal. This method of counting is the only *consistent* way to properly use the powerful dataset that I have amassed through the years. One thing is certain, when using my dataset to look at the Regal, my yield of hours-per-Regal is going to look *very* dismal. In fact, the numbers I am about to present should be looked upon as a worst case scenario. A dataset like this one can be manipulated in any number of directions that I want, and my herpetological yield will look better. What I *can't* do is make it

look any worse. Without any further ado, please refer to Figure 2 below.

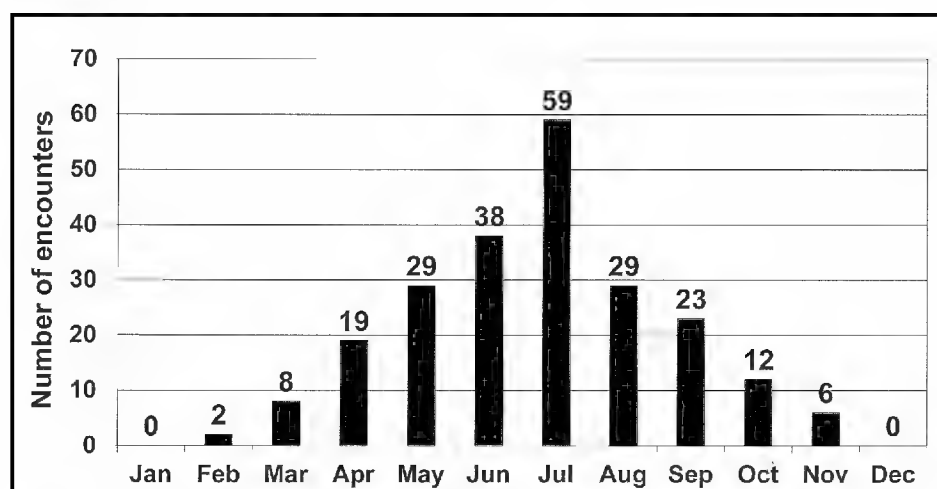


Figure 2. Distribution by month of 225 encounters with *Phrynosoma solare* over the course of 3,370 field trips made by the author and his colleagues during the years 1995–2016. The estimated field hours during this time period totaled 37,070, leaving us with one encounter per every 165 hours of searching.

A Regally rare horned lizard?

One Regal for every 165 hours of searching? Ouch! That kind of number might be cause for either immediate listing under the protective provisions of the Endangered Species Act, or suggestions that my friends and I start selling pencils on street corners. But bear in mind that we are looking at the entire calendar year with this timekeeping vs. hours-per-random-encounter effort. Were we to eliminate December and January, the two “zero” months on the graph, the hours per Regal would improve. But if we cut those months out of the graph, I would lose large numbers of lyresnakes, tortoises, Gila Monsters, rattlesnakes etc. that so perfectly set up comparisons between species of herps over specific periods of time. Nope! We ain’t taking any months out of my herping year for any reason. Field herpetologists tend to bury the number zero by dropping any mention of that number. This author does not consider the number zero a failure, but rather, a number that is just as important as the higher numbers when long-term data and numbers are presented in a consistent manner. In the case of Regal Horned Lizards, I take the number zero in December and January to mean that they become damn scarce, or rarely seen, during those two months. (But they *can* be active then. See Sullivan and Sullivan, 2016.) The graph that you are looking at did not exist two weeks ago. The temptation to blather on and on about it is very great. We could easily halve the number of hours per Regal simply by eliminating all nocturnal field trips. But we *do* on occasion find Regals active nocturnally. (See also Lara-Resendiz et al., 2016.) Nope, I’m *not* cutting out those nocturnal trips either. If I cut anything out, too many other comparative herp numbers fall accordingly. Although much more could be said, I will end all discussion about Figure 2 by saying that I do *not* think of the places that I go as being the very best places to find Regal Horned Lizards. When I *really* want to find a Regal, I head for the grasslands to the south of Tucson. They are roughly 1,000 feet in elevation higher, and closer to the center of their known range. I usually take out-of-town folk who want to see a Regal to places like the towns of Green Valley, Sahuarita, or Robles Junction. As these words are written, powerful forces are urging me to get on my horse and ride in those directions *right now*. I do believe that I will spend some time down that way very soon!

A rainy day opportunity

On 13 July 2014, the author was blessed to witness something with the Regal Horned Lizard that can best be placed in the “more luck than brains” department. On this day, I happened to be paying a social call on a non-herpetologist friend and his family. (Yes, it’s hard to believe, but normal people are all around us. What’s even *harder* to believe is that I would know any.) On this day, my wife Dianna and I were at the home of Jeff and Lori Peterson. They live in an unincorporated area on the way, way, *way* west side of Tucson. The vicinity of their mobile home is one where there is roughly one dwelling per every two acres. The roads leading through the neighborhood are all rugged dirt and gravel, and quickly lead to dead ends. Hence, they do not receive any non-essential traffic. The area also abuts the west side of Saguaro National Park West. What we are talking about is what I am calling a semi-urban Regal Stronghold type of neighborhood. Jeff’s back yard is roughly an acre square in size. A large garage and workshop occupy the northwest corner of the property. The terrain is flat, the soil is friable sandy loam, and the landscaping is almost entirely well-established native plants. We speak of islands of creosote, hackberry, buckhorn cholla, and palo-verde and mesquite trees. Clumps of knee-high Bermuda grass are scattered about. Nearly half the yard has no plant life, and the open areas contain several harvester ant nests. It is tempting to call these nests “harvester ant mounds,” but they are not mounds at all. They are flat, featureless and completely devoid of any form of plant life. They are obvious to the discerning eye, circular in shape, and pockmarked with holes ranging from the barely visible to the diameter of a dime. Jeff does not poison these ants, and the importance of a healthy harvester ant population can’t be overstated where Regal Horned Lizards are concerned. On 13 July 2014, Jeff and I were sitting under the awning of his elevated back porch for most of the afternoon. We were engaged in the pleasant pastime of shooting toy army soldiers with our BB rifles. There were also shots of other varieties being exchanged. My non-herper friend Jeff knows how to have fun! At about 1600 hours, some scattered thunderheads began to gather over Jeff’s neighborhood. The heavens opened to full throttle, and a deluge began. Less than five minutes into the gully-washer of a storm, Jeff’s backyard suddenly seemed to squirm to life, especially under the Bermuda grass patches. Hand-sized lumps of murky-colored blobs wiggled out of these grass clumps, and briskly scampered into the open areas of the yard. By the time these muck-infested blobs stationed themselves close to the entrances of five different harvester ant nests, the rain had washed them clean. It was only then that we could ascertain that these mobile globs of muck were Regal Horned Lizards. I’m going to be quick to add that there were initially more than five observed on this, the day that Jeff’s backyard squirmed into life. How many more, I can’t be sure. Easily ten, but it happened so fast that by the time I realized what was happening, only five were left on open ground for me to count. Each was positioned near a different harvester ant nest. The rain lasted less than 15 minutes, but Jeff’s rain gauge indicated that 1.2 inches had fallen in that very brief period of time. As soon as the rain stopped, the harvester ant nests exploded into life. There could not have been less than a hundred emerging from each dime-sized hole. The five Regals under observation



Figure 3. Harvester ants (*Pogonomyrmex rugosus*). These comprise roughly 90% of the diet of the Regal Horned Lizard. The sting of these ants packs an amazing venomous wallop, and the powerful mandibles are a force as well. Imagine eating hundreds of them in one sitting! Image by Chip Hedgcock.

bent their spiked heads downward, and “blip-blip-blip-blip,” began adeptly plucking ants off the ground. They remained oblivious to the ants that they were not eating, even when those ants began to mob their heads and bodies! At times, they would lick one off their own face or forearm. I could easily have spent hours watching this feeding frenzy, but Jeff’s four grandsons got into the mix. They were aged from 8 to 15 years old, and had a field day capturing the lizards and showing them off to us. It was all a delightful experience, and highly educational for me. While I already knew that the diet of the Regal is largely composed of harvester ants (Figure 3), this day was the only time that I have ever observed Regals feeding on them. The way the rain brought both predator and prey from out of nowhere was noteworthy. There can be little doubt that the predators knew exactly where to go once the rain sprang them. The event also demonstrated why July may be my best month for seeing them. While I only rarely venture out in the rain while it is happening, I am often timing my arrival to get someplace just after a good storm subsides.

Two gapes and a hiss that we don’t want to miss

On 26 April 2008, Annamarie Saenger and Steve Ressel joined me for an all day fun-in-the-sun adventure. On this fabulous day, we encountered 11 species of lizards (some of which were *definitely* above average), totaling exactly 300 individuals. One of the highlights of the day occurred at 1320 hours, when an adult (~100 mm SVL) Regal waddled across the jeep trail that we were driving. While Annamarie and Steve photographed the lizard, I took some microclimate data. The shaded ambient temperature was 32.5°C (90.5°F), the ground temperature was 44°C (111°F), and the hot spot (thermometer in direct sun on ground) was a scalding 55°C (131°F). I also got the exact location with my Garmin GPS. At some point during the photography, the poor horny toad became verklempt, or overheated, or both. It gaped mightily at us (Figure 4)! It seems 2008 must have been a good year for this, for on 10 June, Tricia Saenger (Annamarie’s mother) and I had a 70 mm SVL Regal not only



Figure 4. Gaping, sometimes accompanied by hissing, is a behavior that Regals display. See text for details. Image by Annamarie Saenger.

gape at us, but hiss at us as well! Once again, it was a very hot day, and we were messing with it mightily while trying to get photos. The fact that my half-deaf ears heard the hiss means that the little thing had quite the blow on it! What I remember are three “psst-psst-psst” sounds, that occurred as fast as one can snap their fingers. As mentioned earlier, Brian Sullivan has been using radio-telemetry to study a population of Regals near Phoenix. Brian told me that he sees the gaping commonly, mostly from Regals who are in the hot sun feeding at harvester ant nests (Brian Sullivan, pers. comm.) But he had not heard the hissing. Wade Sherbrooke rang in two days later with a paper he had done. He used an oscillogram and a frequency spectrogram (hissograms?) to illustrate the bionic-man-intro-like acoustic characteristics of the Short-horned Lizard’s hiss (Sherbrooke and Greenfield, 2002). I can’t believe that I left my high quality audio equipment at home this day. How careless of me!

Reproduction, as seen through the lit, lenses and eyes of others

The author has never observed mating or nesting with the Regal. But he *has* paid rapt attention to the works of others, especially those who have never even considered publication of their observations. From the 1990s to the early Y2K years, I managed to lay hands on some 35 mm slide images of some very impressive behaviors. For example, I have five different images of either courtship or mating. It is interesting to note these five images were two more than was known to occur in the history of Arizona, dating back to 1973! (See Van Devender and Howard, 1973.) The dates of copulation range from late June to August. These dates dovetail nicely with Brian Sullivan’s recent revelations, which transpired at some point after 2015. Sullivan’s observations of nine courtships and one mating episode occurred between 11 June and 24 July. The mating episode happened on 30 June, and lasted five minutes (Sullivan and Sullivan, 2017). Because I can, I am including an image of mating (Figure 5). Photographer Chip Hedgcock also suggested five minutes as the time duration of intromission. I’m jealous!

Moving on to that other side of reproduction—nesting, egg laying and hatching—I’m sure that even Drs. Sullivan and Sherbrooke will agree with me when I say that we are collectively in our infancy with our knowledge. Sullivan (pers. comm.) reports that he has observed nesting 22 times over the course of six years. These nesting events occurred between 1 and 15 August,



Figure 5. A *genuine* pair of horny toads. (Mating Regal Horned Lizards.) Image by Chip Hedgcock, taken ~1 July 1994.

but he has yet to witness any hatching. Sherbrooke has cards that he isn't showing, but the whole deck will be laid out soon enough for the likes of all of us. Through a process best known as more luck than brains, I am showing what may be the most complete Regal nesting sequence in the world with Figure 6. The best paper on nesting in my hands again goes back to 1973. It suggests egg laying on 10 July, and hatching on 30 August. Our female Regals can really pack a hefty load, as anywhere from 7 to 33 eggs have been observed in the nests (Van Devender and Howard, 1973). All evidence points to at most one clutch per year occurring (as suggested in Rorabaugh, 2018). Finally, again because we can, we show two more images of hatchling Regals. Were there such a thing as a cuteness Richter scale for herps, these two wee-ones would register a ten! (Figures 7 and 8).

A golly-gee tale about an above-average lizard

There is nothing more fascinating to young boys than a hole in the ground, especially if it is one of their own making. In November of 1982, my seven-year-old son Tim and a gang of youngsters of similar age decided they were going to dig for gold. They chose the field behind my house for their enterprise. They had not gotten very far when they unearthed a hand-sized adult Regal. Knowing my love of all things reptilian, they brought the lizard to me. Under my direction, they filled an

empty ten-gallon aquarium half full of loose dirt. We put the Regal into the aquarium, admired it a while, and then put the aquarium in the metal shed behind my house. The intent was to release the lizard when the weather warmed up. Hindsight being what it is, the shed proved to be a very poor choice as a place to keep the lizard. All of my yard tools were kept there. Hence, it was a place that I largely avoided. The horny toad was forgotten nearly as soon as it was placed inside that shed. It was not until June, when weeds threatened to overtake my house, that I entered the place. As soon as I did, I saw that aquarium and was reminded of my November misdeed. My heart sank, as I feared the worst for that poor horny toad. With great apprehension, I dug into the dirt with my hands. I expected to find a regally mummified horny toad. Imagine the relief and joy that I felt when that lizard scrambled to the surface after the second handful of dirt was scooped up. It seemed to be just fine, despite being entombed in a very hot and dark shed for over six months. Seven months, no food, no water, no problem! It was released close to its place of capture, and promptly scrambled into a soil hole near my son's goldmine. From what I now know about Regals, I'm reasonably sure that it was none the worse for the wear after the experience. Do I think a lizard like this ought to be considered above average? I leave the answer up to you!

This here is Roger Repp, signing off from Southern Arizona, where the turtles are strong, the snakes are handsome, and the lizards are above average.

Dedication

I am dedicating this article to myself. My own tireless devotion to the horny toads of Arizona continues to inspire me to reach levels that I never thought possible. We can realistically say that without me, none of this column would have been possible.

Acknowledgments

The author is first and foremost indebted to Drs. Wade Sherbrooke and Brian Sullivan for being so helpful during the early versions of this effort. I also want to mention Dr. Phil Rosen who, during the time I was writing this column, passed away after a courageous battle with kidney cancer. Phil was busily preparing the results of his own radio-telemetry efforts with the Regal as life was ebbing away from him. Thankfully, some of



Figure 6. (Left) Female Regal Horned Lizard digging a nest. (Center) The same female carefully disguises the nest with twigs and grasses, and rests on top of the now buried nest chamber. (Right) Hatchling Regal emerging from nest hole. Images taken by Dennis Caldwell, 21 July 2001 (left and center), and ~8 September 2001 right. The nest was in his back yard, which is located near the University of Arizona in Tucson, Arizona.



Figure 7. Hatchling Regal Horned Lizard (*Phrynosoma solare*) posed on top of a nickel for size perspective. The dirt patch on the forehead, and the timing of the photo, lead us to speculate that this hatchling may have just emerged from the nest. Image by Dr. Cecil R. Schwalbe, 11 September 1988.

the reproductive information from his study is now in the hands of Dr. Sherbrooke. I also wish to thank the photographers who have so generously loaned me their images. In order of appearance, they are: Charles “Chip” Hedgcock, Annamarie Saenger,



Figure 8. Regally cute! Hatchling Regal Horned Lizard (*Phrynosoma solare*), included because it is a nice image of an *adorable* little lizard. Image by Dale S. Turner

Dennis Caldwell, Dr. Cecil Schwalbe and Dale Turner. Not a single one of these photographers could begin to understand how important some of the clicks of their shutters can be. They each knocked one out of the park with their submissions here. Thank you all!

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Herpetology 2020

In this column the editorial staff presents short abstracts of herpetological articles we have found of interest. This is not an attempt to summarize all of the research papers being published; it is an attempt to increase the reader's awareness of what herpetologists have been doing and publishing. The editor assumes full responsibility for any errors or misleading statements.

DOES CARNIVORY PAY OFF FOR TOAD TADPOLES?

O. Craioveanu et al. [2019, *Herpetozoa* 32:21-31] note that natural diets of anuran larvae vary widely in their relative amounts of nutrients, and the proportion of these ingested nutrients has significant influence on larval and post-metamorphic performance. The authors use the common toad, *Bufo bufo*, to address the role of diet (exclusively carnivore, exclusively vegetarian, and mixed) on growth and development of tadpoles and short-term carry-over effects on post-metamorphic animals. Larvae fed on an exclusively vegetarian diet performed better (faster growth and development) than larvae fed on exclusively carnivore and mixed diets. Larvae fed on the exclusively carnivore diet had the lowest performance. Regarding the carry-over effects of larval diets, although the body condition indices of the toadlets were similar in all treatments, there was a major difference in the survival rate. While toadlets originating from larvae fed on a vegetarian diet were more successful and had the lowest mortality, those fed on a carnivore diet had the highest mortality level. These results suggest that a plant-based diet may contain all the necessary nutrients needed by *Bufo bufo* larvae. Furthermore, a diet based exclusively on food of animal origin might be detrimental for the larval performance and could have significant carry-over effects on the post-metamorphic animal.

MASSASAUGA OVERWINTERING HABITAT

A. R. Yagi et al. [2020, *Journal of Herpetology* 54(2):235-244] note that temperate snakes occupy overwintering sites for most of their annual life cycle. Microhabitat characteristics of the hibernaculum are largely undescribed, yet are paramount in ensuring snake survival. The authors hypothesized that snakes survive hibernation within a vertical subterranean space that they termed a "life zone" (LZ), that is aerobic and flood and frost free throughout winter. They studied an isolated, endangered population of massasaugas (*Sistrurus catenatus*) inhabiting an anthropogenically altered peatland and monitored the subterranean habitat during a period of environmental stochasticity. Initial radio telemetry confirmed that snakes moved between altered and natural habitats during the active season and showed hibernation-site fidelity. A grid of groundwater wells and frost tubes was installed in each hibernation area to measure LZ characteristics over 11 consecutive winters. The LZ within the impacted area was periodically reduced to zero during a flood-freeze cycle, but the LZ in the natural area was maintained. Model selection analysis revealed that soil depth and flood status best predicted LZ size. Thermal buffering and groundwater dissolved oxygen increased with LZ size, and annual massasauga encounters were significantly correlated with LZ size. This analysis suggests a population decline occurred when LZ size was reduced by flooding. The data give support to the importance and maintenance of an LZ for successful snake hibernation. The methods used apply to subterranean hibernation habitats that are at risk of environmental stochasticity, causing flooding, freezing or hypoxia.

FOOD SPECTRUM OF COMMON KRAITS

D. P. Pandey et al. [2020, *Journal of Herpetology* 54(1):87-96] note that common kraits, *Bungarus caeruleus*, cause thousands of fatalities annually in Asia. They aimed to examine stomach contents of preserved kraits to determine their most favored prey animals that might attract them to residences where they bite sleeping people, even under mosquito nets. They examined freshly killed *B. caeruleus* and those preserved in collections maintained in hospitals and museums during July 2016 to October 2018 to identify contents of their stomachs and intestines. Among 61 examined *B. caeruleus*, three kraits consumed frogs, three consumed snakes, one consumed a bird, and five consumed rodents. This is the first comprehensive study of the food spectrum of *B. caeruleus* for Nepal and the third study worldwide. Unlike previous findings, this one found the snakes mainly feeding on nonsnake prey animals. Most snakes having empty stomachs and a few specimens with freshly eaten prey animals indicated their entry into dwellings in search of prey animals was because of food stimuli. Findings of partly digested rodents, frogs, snakes, and avian prey (which are commonly found in houses in the lowlands of Nepal) further support food stimuli to be an important factor driving *B. caeruleus* to residential areas, where they often cause envenomation (69% of total specimens involved in snakebite, $n = 42$). The findings can be extrapolated to understand the feeding ecology of *B. caeruleus* distributed in residential areas and to formulate effective prevention strategies against their bites. Implementing effective and practicable prevention strategies lessens the fear of snakes. This consequently minimizes unnecessary killing of snakes, which in turn contributes to biodiversity conservation.

ALLIGATOR SERUM INHIBITS PITVIPER VENOM

J. W. Finger Jr. et al. [2020, *Journal of Herpetology* 54(2):151-154] note that American alligators (*Alligator mississippiensis*) are known to consume venomous pitvipers, apparently with no ill effects. Alligators handle venomous and nonvenomous snakes similarly during consumption, indicating that alligators may possess a physiological resistance to venom. This study tested the ability of alligator blood sera to inhibit the activity of two toxins in eastern copperhead (*Agkistrodon contortrix*) venom, hemolytic toxins and snake venom metalloproteinases (SVMP). Specifically, the authors compared relative venom activity following incubation with alligator sera to a venom-only control as well as venom incubated with serum from a species lacking venom resistance (house mouse; *Mus musculus*). Alligator sera significantly reduced SVMP activity, although they observed no effect of alligator sera on hemolytic activity. Interestingly, they detected individual variation with respect to hemolytic activity such that inhibition was positively related with both alligator length and body condition. The results provide evidence that alligator serum is capable of inhibiting at least one of the primary toxins present in pitviper venom.

LEOPARD FROG CONFUSION

G. B. Pauly et al. [2020, *Copeia* 108(2):299-308] note that lowland leopard frogs (*Rana yavapaiensis*) have experienced extensive population declines over the last century. In California, this species was historically known to occur in scattered localities in the extreme southeastern portion of the state, but it has not been positively documented since 1965. Subsequent to this decline in California, nonnative Rio Grande leopard frogs (*R. berlandieri*) have expanded into localities previously occupied by *R. yavapaiensis*. The lack of extensive formal surveys and the difficulty distinguishing between these species using morphological characters have caused uncertainty about whether lowland leopard frogs persist within their historical range in California. Recently, leopard frogs that could not be confidently identified to species have been observed at historical localities of *R. yavapaiensis*. Thus, the authors undertook a formal study of these populations to characterize their morphological and genetic variation, and conclusively determine to which species they belong. Their genetic analyses demonstrate that these frogs are *R. berlandieri*, but the morphological characters typically used to diagnose these species are largely overlapping. Further complicating field identifications, for some morphological characters, the California *R. berlandieri* are more similar to *R. yavapaiensis* than to native-range *R. berlandieri*. Additionally, invasive *R. berlandieri* show greater variation in a key character—the condition of the inset dorsolateral folds—than that found across much of the species' native range. These results demonstrate the potential for morphological change during rapid population expansions to confound species identifications. The findings from this study have implications for future efforts to resolve the status of *R. yavapaiensis* in California and to identify other native leopard frogs found within the expanding range of *R. berlandieri*. The results also highlight the utility of genetic approaches for reliably identifying morphologically similar leopard frogs.

PHYLOGEOGRAPHY OF MUDDUPPIES

K. Greenwald et al. [2020, *Journal of Herpetology* 54(1):78-86] note that the geology of the Pleistocene, and particularly the Last Glacial Maximum approximately 26.5 ka, is a critical driver of species present-day distributions and levels of genetic diversity in northern regions. Using mitochondrial DNA sequence data, the authors tested several predictions relating to the postglacial recolonization of the northern United States and southern Canada by mudpuppies (*Necturus maculosus*). The analyses revealed a significant split between western and eastern lineages, with the divide corresponding to the location of the Mississippi River. The data support the presence of one or more Mississippian glacial refugia, with subsequent expansion and diversification of a western cluster into the upper Midwest and an eastern cluster into the eastern Great Lakes and New England. As predicted in cases of postglacial colonization, each of these clusters contains a single widespread and common haplotype along with numerous low-frequency, closely related haplotypes. Given recent conservation concerns about amphibians in general, and Mudpuppies specifically, the authors discuss the results in light of species conservation. Knowledge of a species' genetic diversity allows for informed management and facilitates decisions that preserve local adaptation and evolutionary potential.

RELOCATED BOX TURTLES

J. M. Orr et al. [2020, *The Herpetological Bulletin* 151:6-9] note that the eastern box turtle, *Terrapene carolina carolina*, is a long-lived turtle species that is declining across much of its range. A mark-recapture study of this species was carried out for over 30 years at the Mason Neck National Wildlife Refuge in Virginia. During this time, box turtles were relocated to the reserve and became part of the study. Several individuals were recaptured more than ten years after relocation including one that was recaptured after almost 28 years. Overall, however, turtles relocated to the study area appeared not to fare as well as resident turtles. Significantly fewer relocated turtles were recaptured after their first winter at the new site (33.3%) than resident turtles (51.5%) though the survival rates for relocated and resident turtles were similar for subsequent years. Relocation can work as a rescue strategy for some individuals but it can also negatively impact relocated individuals. This study is the first to show long-term residency of relocated box turtles.

SKIN MICROBIOTA IN CAPTIVE FIRE SALAMANDERS

C. J. Michaels and R. F. Preziosi [2020, *The Herpetological Bulletin* 151:10-16] note that the fire salamander (*Salamandra salamandra* and its relatives) is of increasing priority for ex situ conservation due to the spread of the fungal pathogen *Batrachochytrium salamandrivorans* in Europe. In captivity, the species may be maintained on a clinical paper-based or a naturalistic substrate, either of which has its own advantages and disadvantages. However, the impact of these two substrates on bacterial microbiotas within an enclosure and on the salamanders themselves is unknown. To investigate this, the authors maintained captive fire salamanders on either paper towels or a naturalistic substrate and quantified the culturable microbiotas of both substrates across the one-week lifespan of a paper towel and of the salamanders themselves over a six-month period. They found significant differences in the bacterial communities associated with the two substrates. Over a week-long period, there were major fluctuations in the community composition and abundance on paper towels while on the naturalistic substrate bacterial communities were relatively stable. The skin microbiota of salamanders were indistinguishable at the beginning of the study but after six months differed significantly between the two treatments, although the bacterial morphotypes present remained relatively similar compared with changes between substrates. These data show that husbandry protocols may have a strong influence on the culturable bacterial communities to which captive amphibians are exposed. Nevertheless, the animals were apparently able to maintain their own microbiota to a considerable degree. These findings should be borne in mind when determining husbandry protocols. Given the relative benefits of both types of enclosure, it is possible that a hybrid approach could be used whereby a small amount of naturalistic substrate is provided in a container within an otherwise clinical enclosure, to act as a bacterial reservoir.

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For sale: *That Vanishing Eden—A Naturalist's Florida* by Thomas Barbour; 1944 (first edition); 250 pp., b&w photos; Barbour and Archie Carr were friends; small piece missing from DJ and newspaper reviewer info written on front piece, otherwise excellent condition; mylar covered DJ; (h) - \$75;; *Reptiles and Amphibians of the Cimarron National Grasslands, Morton County, Kansas* by Joseph T. and Suzanne L. Collins; 1991; 60 pp., 40 color photos; (s) - \$15; *Hawaiian Reptiles and Amphibians* by Sean McKeown; 1978; 80 pp., many color photos, some double page; (s) - \$12; *Forty Queensland Lizards*; 1973; ; 84 pp., many b & w drawings, range maps; published by the Queensland Museum; 5 families; (s) - \$15; *Amphibians & Reptiles in West Virginia* by N. Bayard Green and Thomas K. Pauley; 1987; 241 pp., 85 color photos; scarce (s) - \$45; *Guide to the Reptiles and Amphibians of the Savannah River Site* by J. Whitfield Gibbons and Raymond D. Semlitsch; 1991; 131 pp., 17 figs. (b & w drawings), maps; like new (h) - \$18; *Fauna*; premier issue, vol. 1, no. 1, 1997; 80 pp. magazine handsomely illustrated with outstanding color photos; 10 pp. article on the common tree boa by Robert Henderson; 8 pp. on eublepharid geckos by L. Lee Grismer; 6-page report of a field trip in Colombia by William L Lamar; 8 pp. on illustrations of reptiles by Kraig Adler; a 6 pp. rollicking profile of Jonathan Campbell by James B. Murphy among other articles. (s) - \$15; *Australian Geographic*; July-Sept., 1994; 12-page article by Richard Shine on his (and others) research in Kakadu National Park on the noteworthy file snake (i.e., uses oxygen at half rate of other snakes, females take 7 yrs. to mature,, probably reproduce only once every 10 yrs; population size has been recorded at 1/2 ton biomass per hectare); 24 pp. on West MacDonnell National Park; comes with detailed poster (19" x 27") folded map of Antarctica; *Geographic* quality color photos; perentie on cover; 128 pp. of Australiana. (s) - \$15. All publications in excellent condition unless otherwise noted. \$4 postage for orders under \$25, postage paid for \$25 and over. Send email for complete list. William Turner. toursbyturner@aol.com, (303) 795-5128.

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NEW CHS MEMBERS THIS MONTH

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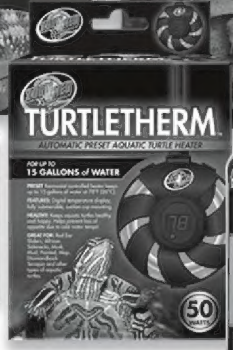
















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News and Announcements

2021 CHS HERPETOLOGICAL GRANTS PROGRAM

The mission of the Chicago Herpetological Society is education, conservation and the advancement of herpetology. To further this mission, the CHS provides grants of up to \$1,000 in the following categories:

1. Illinois Herpetology
2. Graduate Student Research in Herpetology
3. Undergraduate Research in Herpetology
4. Conservation
5. Captive Management, Husbandry and Propagation

The number of grants awarded in each category will depend on the grant applications received; it is possible that not all categories will receive awards and some categories may receive more than one award. The Grants Committee reserves the right to reassign the category under which a given proposal is submitted.

To qualify for a grant, the applicant must be a member of the Chicago Herpetological Society as of December 31, 2020. In accepting a grant, the recipient agrees to acknowledge the Chicago Herpetological Society in any publications or public presentations of research funded by this grant. Further, the recipient agrees to abide by all state and federal laws.

Recipients must submit a short report of their research findings to the CHS within 6 months of their anticipated completion date. The report should be written for a general audience and be suitable for publication in the CHS *Bulletin* or on the CHS webpage. This requirement may be waived if results will be published in a peer-reviewed journal within a year. Recipients may be invited to present a program at a CHS general meeting.

Applications must include the following:

1. Project title
2. Applicant's name, address, phone and email
3. Submission category
4. Introduction—Provide background for the proposed work. Include a clear statement of the objectives of the proposed work.
5. Materials and methods—Describe the study site and the materials and methods (in non-technical terms) that will be used to accomplish the objectives of the proposed research. Attach plans, diagrams and maps as necessary. Indicate whether you have an approved Animal Care (IACUC) protocol covering the proposed methods or whether you will be submitting such a protocol.
6. Applicability and broader implications—How does this work apply to conservation, education and the advancement of herpetology?
7. Budget—Indicate the budget for the entire project and make clear what portion the CHS grant money would fund.
8. Anticipated completion date for the research
9. Applicant curriculum vitae
10. Letters of support—Student applicants must include a letter of support from a faculty advisor. For non-academic individual and institutional applicants, letters of support from collaborating partners or institutions are strongly encouraged. Letter(s) of support may be emailed and should include an address and phone number at which the writer can be contacted. Letter(s) of support may also be sent by postal mail.

Proposals should be submitted as email attachments. Attachments should include the applicant's name in the file name. Proposal text should not exceed five double-spaced pages (excluding literature cited, applicant's CV, and letters of support) and should be typed using a common font (e.g., Arial, Times, Courier) no smaller than 10 pt. Applications must be received by December 31, 2020, and awards will be announced by February 15, 2021.

Proposals or questions should be emailed to grants@chicagoherp.org

UPCOMING MEETINGS

Until in-person meetings again become possible the Chicago Herpetological Society will begin having monthly general meetings online via Zoom Webinar. These meetings will take place on the last Wednesday of each month at 7:30 P.M. Chicago time. Find information about attending a Zoom Webinar here:

<<https://support.zoom.us/hc/en-us/articles/115004954946-Joining-and-participating-in-a-webinar-attendee->>

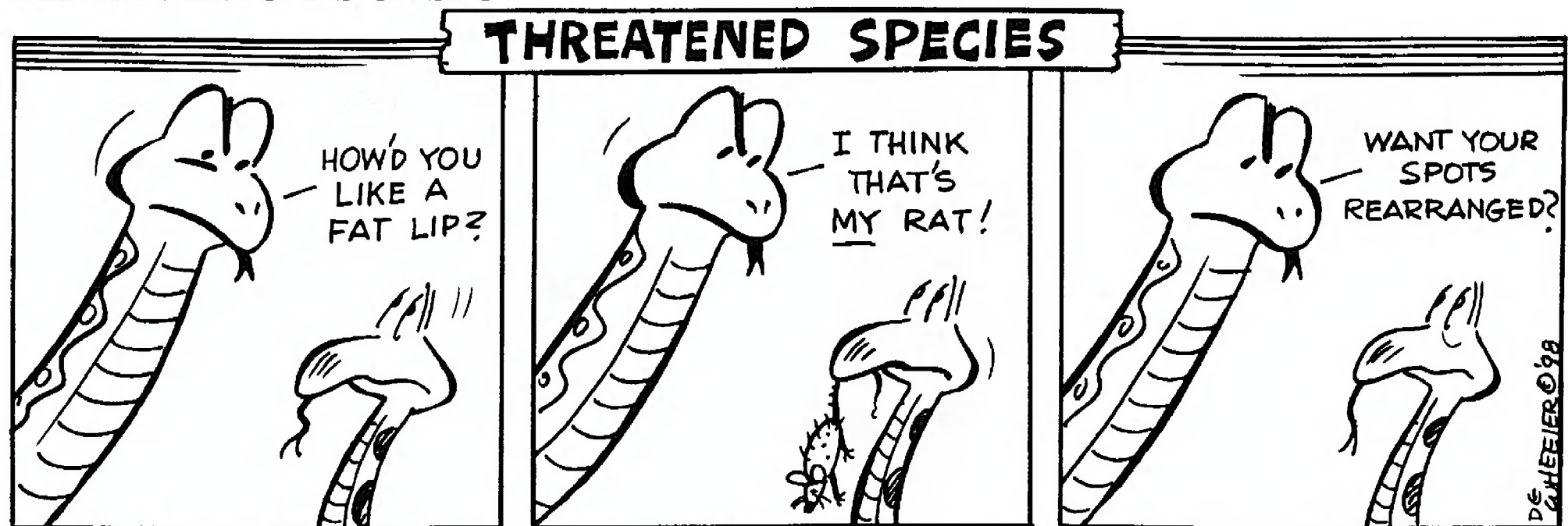
Deb Krohn will be speaking at the next meeting, which will take place via Zoom on October 28. Deb will be strolling down her CHS memory lane using several live animals she's adopted over the years. You'll see many of Deb's favorite and beloved herps all while highlighting people and events that have made her personal history with the CHS so incredible.

Deb Krohn has a bachelor's in Wildlife Biology from Iowa State University and has been a professional naturalist since her graduation in 1996. She runs her own environmental education business called FrogLady Presentations where she teaches thousands of children and adults every year on a variety of nature topics but specializes mostly in herpetology. Deb has been a member of the CHS for almost 20 years and has also served on the board. She lives in Grayslake with her husband, son, over 50 herps and the world's cutest dog.

Board of Directors Meeting

Are you interested in how the decisions are made that determine how the Chicago Herpetological Society runs? And would you like to have input into those decisions? The next board meeting will be held online. If you wish to take part, please email akolb@chicagoherp.org.

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